STUDIES OF YIELD, LEAFINESS, HCN, HELMINTHOSPORIUM LEAF BLIGHT, AND OTHER MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS IN CERTAIN SUDANGRASS VARIETIES AND LINES

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1950

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

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INTRODUCTION

The purpose of this experiment has been to study variations and relationships of prussic acid potential, Helminthosporium leaf blight, and certain other morphological and physiological characteristics of sudangrass, Sorghum sudanese (Piper) Stapf.

Sudangrass is one of the most valuable summer annual forage grasses. Like other sorghums, it tolerates droughty conditions and its rapid growth from late sowing makes it an ideal supplemental forage for pasture, hay and silage. Another use is as an emergency forage crop for late planting.

Sudangrass is adapted to most regions of the United States where sufficient moisture is available to produce crops. It compares favorably with other forage crops in amount of yield, palatability, and total digestible nutrients. It possesses certain agronomic characteristics, however, which may reduce its forage value. Some of these characters are; susceptibility to disease, high prussic acid potential, and the unfavorable ratio of leaves to stems.

Prussic acid potential exists in the plant as a cyanogenetic glucoside, dhurrin. It does not affect horses and swine but may be fatal to ruminants. The deadliness is thought to be determined by the amount of glucoside taken into the body and the rapidity with which it is consumed.

The prussic acid potential of the plant decreases with the age of the plant. It is relatively safe for grazing after the plant has attained a height of two or three feet. It will produce four to six animal unit months of grazing or one to seven

tons of hay depending upon soil fertility and rainfall.

Helminthosporium leaf blight is the most severe disease of sugandgrass in Kansas. This disease may cause slight to complete defoliation depending on the inherited resistance or susceptibility and the climatic conditions. Leaf blight epiphytotics are more common during periods of cool weather with high humidity in mid to late summer. Heavy dews present favorable environmental conditions for spore germination and inoculation of the plant. Hot dry seasons are often accompanied by lack of a leaf blight epiphytotic, thus progress in the breeding program for resistant varieties may be retarded.

Sudangrass has certain visible morphological characteristics such as leaf width, leaf length, maturity dates, height, and number of leaves per stem. The relationships of these characters to each other and to other less prominent characters are not thoroughly understood. These characters may prove valuable for use in selecting better varieties of sudangrass, once these relationships are worked out.

The number of generations required for study in developing a new variety of sudangrass, makes the process a long and expensive one. Thus there is the need for greenhouse technics for studying disease incidence and potential prussic acid content which will give results comparable to those found in field conditions.

LITERATURE REVIEW

Potential Prussic Acid Content

A major disadvantage to the use of sudangrass as a pasture crop is the potential danger of prussic acid poisoning. Avery, according to Vinall, H. N. (14) stated that 0.4 grams of prussic acid is sufficient to produce severe symptoms of poisoning, and 0.6 grams would probably be fatal to a mature animal, and that 19 pounds of green sudangrass were required to provide sufficient prussic acid to be fatal to a mature cow. Cough and Briese (3) reported that about 50 percent of the potential prussic acid was liberated over a period of three to four hours, and the rate at which it was liberated was determined by the activity of one or two enzymes found in the plant. Unless the enzyme is sufficiently active to evolve a toxic quantity of prussic acid quickly, poisoning is not likely to occur. Boyd, et al (2) reported that the amount required may vary some depending on the detoxifying capacity and physical resistance of the animal.

According to Boyd, et al (2) a 1000 pound cow should be able to detoxify at the rate of 1.5 grams of prussic acid per hour. It is therefore possible for cattle to consume forage containing small amounts of cyanide without ill effects or symptoms of poisoning. It is only when the poison enters the blood stream at a rate greater than the detoxifying rate of the animal that fatal poisoning follows (2).

Franzke, et al (5) Hogg and Ahlgren (7) Williaman and West (16) reported that the inheritance of prussic acid potential is

controlled by one or two major factor pair and several modifying factors. Snyder (12) at Wisconsin reported that it is controlled by one major factor pair and possibly a few modifying factor pairs, and that a low prussic acid is linked with the gene for purple pigments and high susceptibility to Helminthosporium leaf blight. They agree that the genes for low prussic acid are dominant over the genes for high prussic acid.

Many environmental factors affect the prussic acid potential of sudangrass. Franzke, et al (5), Hogg and Ahlgren (7), Snyder (12), Wayd and Noggle (15), reported that a high nitrogen content of the soil will cause an increase in prussic acid content, and Snyder (12) found that border rows and plants along alley-ways were relatively high in prussic acid. Phosphorus was reported (5), (7), (12), (15), to decrease the amount of prussic acid.

Williamen and West (16) found that droughty conditions caused an increase of prussic acid and (17) that it was concentrated in the stems for the first three or four weeks of growth. Then rapidly disappears there, but remains in the leaves in decreasing percentage until maturity. Drought (15) probably affects the prussic acid content by keeping the plant small by withholding water and probably by lessening the availability of phosphate to the plants more than that of nitrogen.

Helminthosporium Leaf Blight Reaction

Jenkins, et al (9) reported that leaf blight in corn, caused by Helminthosporium turcicm, is controlled by numerous genes. Most of these genes have minor effects, but a few of them are

major factors. Some of these major genes exert greater influence at low levels of infection. The effect of others are at high levels of infection while some genes exert influence over a wide range of levels.

Snyder (12) reported evidence indicating that a single major factor pair of genes in sudangrass is involved in resistance to leaf blight which is associated with tan pigments, juicy midrib, and low vigor.

Drolsom (4) found a highly significant association between field blighting and greenhouse blight. The relationship between seedling and mature plant reaction to disease was not sufficiently consistent to justify a greenhouse program to screen for resistant lines.

Yields and Palatability

Fortmann, et al (6) reported that the relative performance of sudangrass varieties were not the same for all locations. Thus the variety which gives the best performance, in a particular area, should be used in that area, if the seed is available.

In general (6), the percent protein in the forage decreases as yield in dry matter increases. Neal, et al (11) reported that protein content in the forage can be increased by adding nitrogen to the soil.

Livestock prefer to graze species of grass high in moisture and carotene content, and low in fiber (1). Protein content had little relation to the palatability of the grass.

MATERIALS AND METHODS

The 1953 sudangrass breeding nursery was planted in 25 foot rows, 36 inches apart on June 12 and 16. Fifty nine rows were selected, September 26 and 30, for study of leaf characteristics. They were selected on the basis of height, vigor, leafiness, and Helminthosporium leaf blight resistance. Both susceptible and resistant rows were selected. These rows were selected from the first 550 nursery rows. An effort was made to take samples representing as many leaf variations and sources of material as possible.

Six replications of check blocks were dispersed through the nursery to determine any variations due to location in the nursery. These check blocks were used for controls in the disease and prussic acid studies for the 1953 nursery. They contained the following varieties which have been under observation at the Kansas Agricultural Experiment Station: Tift, S-1, 337, 1949-D, Texas Sweet, Beltsville Syn. IV, Greenleaf, Common, K-3, Wheeler, Piper, 372, K-1, Nebr. 50722, Nebr. 483172, and Okla. 130.

Methods of Determining Yields and Dry Matter

A section of row twelve feet long was harvested from each variety in each check block when they were between the full head stage and early milk stage for determination of yield in dry matter, percent dry matter, percent leaves in dry matter, and yield in pounds of leaves on the dry matter basis. All varieties except Okla. 130 were harvested July 12, 13, and 14. Okla. 130 was late maturing and was harvested July 20.

The fresh material was weighed immediately after cutting and

a representative sample from each variety was placed into number 20 kraft bags. It was labeled as to variety, date, weight, and check block from which it came. The bags were placed in the oven and dried for 72 hours at 70° C. It was then reweighed and the percent dry matter was determined. A second representative sample from each variety was wrapped in white paper and labeled. These bundles of fresh material were placed on benches in the greenhouse to dry until September. A small amount of mold had developed on the plant material by this time. The leaf sheath and the leaf blade were separated from the stem, leaving the stems and the immature heads together. The leaves and the stems were wrapped in separate packages with white wrapping paper, labeled, and placed in the oven and dried at a temperature of 70° C. for 48 hours. They were weighed and the percentage dry matter in each determined.

Due to droughty conditions and severe chinchbug injury some of the varieties failed to produce a second cutting. Some varieties produced regrowth on an eight foot section of row. This was harvested, weighed, and converted to yields equal to 12 feet of row. These varieties were: 1949-D and Okla. 130 in check block number 1, Greenleaf and Okla. 130 in check block number 2, and K-3 in check block number 4.

The 1953 sudangrass breeding nursery produced only two cuttings. The regrowth was permitted to grow until there was danger of frost. It was harvested September 19, 23, and 24. Stage of maturity was not taken into consideration for this cutting. It was weighed and representative samples taken and placed in number 20 kraft bags which were labeled as to variety, check block, weight, and date. They were taken to the greenhouse

immediately and placed in the oven, and dried at 70° C. for 72 hours, then reweighed and percent dry matter, and yields of dry matter determined.

The leaves for the second cutting were separated from the stems at the leaf collar, leaving the leaf sheath on the stem. Only the earliest maturing varieties, such as Piper, Wheeler, Nebr. 50722, Nebr. 483172, and Texas Sweet had reached the heading stage. The other varieties were in the late boot stage. The leaves were wrapped in separate packages from the stems. Each package was labeled as before and as to content. It was returned to the oven for 24 hours then weighed. The percentage leaves, and yield in leaves on a dry matter basis was determined.

Table 1. Rows Selected from 1953 Sudangrass Nursery for Study of Morphological Characteristics.

Source	Row Numbers
KS 1044 selection	2
KS 1044 selection	8
KS 1044 selection	11
KS 1044 selection	20
KS 1044 selection	40
Tift selection	50
Tift selection	55
Tift selection	56
Tift selection	59
Tift selection	64
Tift selection	66
Tift selection	67
Tift selection	75
Tift selection	84
Tift selection	87
Tift selection	104
Tift selection	121
(KS 1044 x Sweet) x Tift	132
(KS 1044 x Sweet) x Tift	140
(KS 1044 x Sweet) x Tift	143
Sweet x Tift 246	161
Dwarf Waxy Kafir SA. 58714 x Sweet 161	168

Table 1. (Concl.)

Source	Row Numbers
339-7 x 181	187
82-1-327-3	201
84 x 35	218
Wisconsin observation rows D. C. Smith 1953	234
69 2/10 x 3e	257
J x 44	347
J x 44	349
(J x 4n) x 4n F_4's-J x 4n	352
(J x 4n) x 4n F_4's-J x 4n	357
(J x 4n) x 4n F_4's-J x 4n	359
(J x 4n) x 4n F_4's	371
(J x 4n) x 4n F_4's	374
(J x 4n) x 4n F_4's	380
(J x 4n) x 4n F_4's	384
(J x 4n) x 4n F_4's	386
(J x 4n) x 4n F_4's	388
(J x 4n) x 4n Tift	439
(J x 4n) x 4n Tift	441
(J x 4n) x 4n Tift	443
Juicy Sorghum almum	444
526 x 4n 559	457
972-2 x 791-4 J	460
S. almum x 905-1-439J	468
S. almum x 905-1-439J	470
911 x 4n 860	472
KS 1044 selection	482
KS 1044 selection	488
KS 1044 selection	490
Tift selection	493
Tift selection	499
KS 1044 selection	501
Wisc. observation D. C. Smith 1952	506
KS 1044 selection	514
Wisc. observation D. C. Smith 1952	524
69 2/10 x 3e	528
(J x 4n) F_4's x 4n	545
KS 1044 selection	548

Examination of the data revealed that 13 varieties in check blocks 1, 2, and 4 produced sufficient regrowth for harvest. These varieties are: Beltsville Syn. IV, Greenleaf, Okla. 130, Tift, K-3, Piper, 1949-D, S-1, K-2, Nebr. 483172, Wheeler,

Nebr. 50722, and 337. Data on these varieties were analyzed and studied by means of analysis of variance.

Leaf Studies of Selected Nursery Rows

Fifty nine representative nursery rows were selected from the nursery. Samples of 800 to 1200 grams of green material were harvested for leaf studies from the regrowth, September 26 and 30. An effort was made to select rows which were representative of a wide range of types in the following characters; vigor, leafiness, leaf types, height, tillers, and leaf blight.

Seven representative stems were selected from each sample. The first leaf below the flag leaf on each stem was measured. These measurements consisted of width of each leaf to the nearest millimeter and length to the nearest one tenth of an inch. The number of leaves on each stem were counted and recorded. These stems were then placed back into the samples, and the leaves were separated from the stems at the leaf collar. The stems and leaves were placed in kraft bags, labeled as to content and row number. They were brought to the greenhouse immediately, and dried in the oven at 70° C. They were then weighed and the percentage of leaves determined on a dry matter basis.

Analysis of data from this material were made by calculations of analysis of variance and a correlation coefficients. Materials and sources are listed in Table 1.

A Study of Prussic Acid Content
Under Greenhouse and Field Conditions

Fifty nine clones were selected from the sudangrass nursery in October, 1952. These selections were made on the basis of desirable characters such as leafiness, tillers, vigor, and disease resistance. They were transplanted to six inch pots in the greenhouse for the winter 1952-1953. Their prussic acid content was determined in March, 1953. Each clone was divided into several plants and transplanted to the field June 16, 1953. Prussic acid content was then determined under field conditions. This data was studied by means of correlations to determine if the greenhouse prussic acid content could be used to screen out plants with low prussic acid potential.

The 1952 row numbers were retained throughout the test. Materials and source are listed in Table 2.

Table 2. Studies of Potential Prussic Acid Content in the Greenhouse vs Potential Prussic Acid Content in Field.

Source	Row numbers
KS 1044 selection	8
KS 1044 selection	25
(Leoti-Sudan$_2$) x (Leoti-Sudan$_4$)	K-3
KS 1044 selection	29
KS 1044 selection	32
KS 1044 selection	33
KS 1044 selection	65
Tift selection	69
Tift selection	74
Tift selection	87
Tift selection	99
Tift selection	101
Cody HC 39-142 x Tift 246	260
Dwarf Waxy Kafir SA. 58714 x 161	279
Dwarf Waxy Kafir SA. 58714 x 161	280

Table 2. (Concl).

Source	Row numbers
587-1 x 84	331
339-7 x 181	349
339-7 x 181	353
339-7 x 181	361-3
339-7 x 181	361-4
339-7 x 181	366
707-1 x 224	391
Is B_1 D x 33	409
Tift selection	417
Wisc. Obs.	442
(J x 4n) x 4n Tift	470
(J x 4n) x 4n Tift	482
69 2/10 x 3C	490
69 2/10 C x 51 K	512
4n KS 1044 (32 1/10 D)	519
4n KS 1044 (32 1/10 D)	522
4n KS 1044 (32 1/10 D)	526
4n KS 1044 (32 1/10 D)	530
4n KS 1044 (32 1/10 D)	531
J x 4n	555
1950 2n o.p. from Cross 60 x 169- 1,2 (o.p.)	570
J x 4n	588
J x 4n	590
J x 4n	600
(J x 4n) F_4's x 4n	602
(J x 4n) x 4n F_4's	643
(J x 4n) x 4n F_4's	648-2
(J x 4n) x 4n F_4's	653
Cr 34	708
(J x 4n) x 4n Tift	745
(J x 4n) x 4n Tift	751
526 x 4n 559	810
S. almum x 905-1-439J	823
911 x 4n 860	846
526 x 795-5J	860

Studies of Helminthosporium Leaf Blight Reaction Under Field Conditions vs Greenhouse Inoculation

Greenhouse tests for Helminthosporium leaf blight reaction were made on several hundred lines of sudangrass during the winter of 1952-1953. These tests were used in an effort to screen out lines with a low relative disease reaction for use in the

sudangrass breeding program.

Insufficient space in the greenhouse made it necessary to divide the material into two major tests, thus the operation was extended over a considerable period of time as shown in Tables 3 and 4.

Each line was planted to 3 four inch clay pots and randomized throughout three replications to determine any variation caused by location in the replication. Wheeler, 1949-D Beltsville Syn. IV, K-3, K-2, Piper, and Sweet Sudan were placed at random throughout each block of pots as checks.

Cultured Helminthosporium turcicum spores in water suspension were sprayed onto the foliage of the young plants when they were in the 4 to 5 leaf stage, after which they were incubated under a canvas moist chamber for a period of 48 hours. Dates of inoculation are shown in tables 3 and 4. Adequate infection was obtained by this method.

Table 3. Helminthosporium Leaf Blight, Greenhouse Screening for 1952-53; First Planting.

Block No.	Date planted	Inoculation	Date of Reading	No. of days after inoculation
		Replication no. 1		
1	11/1/52	12/16/52	1/5-6/53	21
2	11/3/52	12/19/52	1/8-9/53	21
3	11/3/52	12/22/52	1/12-13/53	21
		Replication no. 2		
4	11/25/52	1/5/53	1/24/53	19
5	11/25/52	1/7/53	1/29/53	22
6	11/25/52	1/10/53	1/30/53	20

Table 4. Helminthosporium Leaf Blight, Greenhouse Screening for 1952-53; Second Planting.

Block no.	Date planted	Inoculation	Date of Reading	No. of days after inoculation
		Replication no. 3		
1	1/28/53	3/3/53	3/28/53	25
2	1/29/53	3/5/53	4/2/53	28
3	1/30/53	3/9/53	4/6/53	28
		Replication no. 4		
4	2/3/53	3/11/53	4/6/53	26
5	2/5/53	3/13/53	4/6/53	24
6	2/6/53	3/16/53	4/6/53	21

Table 5. Studies of Helminthosporium Leaf Blight Reactions under Field Conditions, vs Greenhouse Screening.

1953 row numbers	Source	1952-53 greenhouse pot number
4	KS 1044 selection	8-1
5	KS 1044 selection	8-2
11	KS 1044 selection	25-1
16	KS 1044 selection	33-3
26	KS 1044 selection	43-3
28	KS 1044 selection	47-1
29	KS 1044 selection	47-2
32	KS 1044 selection	57-3
34	KS 1044 selection	60-1
35	KS 1044 selection	60-2
37	KS 1044 selection	60-3
43	KS 1044 selection	65-2
44	KS 1044 selection	65-3
45	KS 1044 selection	65-4
47	KS 1044 selection	65-6
50	Tift selection	69-4
52	Tift selection	69-6
53	Tift selection	69-1
54	Tift selection	73-4
55	Tift selection	73-2
56	Tift selection	74-1
62	Tift selection	75-3
64	Tift selection	77-2
77	Tift selection	87-2
80	Tift selection	88-1
83	Tift selection	93-3

Table 5. (Cont.)

1953 row numbers	Source	1952-53 greenhouse pot number
84	Tift Selection	93-4
87	Tift selection	99-1
88	Tift selection	99-2
89	Tift selection	99-3
90	Tift selection	99-4
91	Tift selection	99-5
92	Tift selection	101-2
93	Tift selection	101-1
94	Tift selection	101-7
95	Tift selection	101-5
96	Tift selection	101-3
97	Tift selection	101-4
98	Tift selection	101-6
99	Tift selection	102-1
107	Tift selection	110-3
108	Tift selection	110-2
114	Tift selection	115-1
116	Tift selection	116-4
117	Tift selection	116-2
118	Tift selection	116-1
119	Tift selection	116-3
131	(KS 1044 x Sweet) x Tift	196-2
136	(KS 1044 x Sweet) x Tift	216-4
143	(KS 1044 x Sweet) x Tift	221-2
144	(KS 1044 x Sweet) x Tift	221-4
146	(KS 1044 x Sweet) x Tift	221-3
147	Tift x (KS 1044 x Sweet 155)	230-1
149	KS 1044 selection 65 x Tift	234-1
152	KS 1044 selection 65 x Tift	236-1
161	Sweet x Tift 246	243-6
162	Sweet x Tift 246	243-7
171	Dwarf Waxy Kafir SA. 58714 x Sweet 161	280-2
172	Dwarf Waxy Kafir SA. 58714 x Sweet 161	296-1
174	EK x BWM-BKL x Sw.	299-1
178	KS 1044 - 65 selfed x 59 (o.p.)	314-3
179	354-1 x 42 F_2's from '50, '51 GH cross	319-1
180	354-1 x 42 F_2's from '50, '51 GH cross	321-3
185	337-7 x 181	349-2
187	337-7 x 181	349-4
190	337-7 x 181	353-3
195	337-7 x 181	366-1
210	554-2-556-2 x 82	404-4
216	Is B_1 0 x 33	409-1
223	84 x 35	416-2
224	84 x 35	416-4
228	Tift selection	417-5
229	Tift selection	417-6

Table 5. (Concl.)

1953 row numbers	Source	1952-53 greenhouse pot number
249	69 2/10 x 3e	486-3
250	69 2/10 x 3e	486-4
251	69 2/10 x 3e	486-2
255	69 2/10 x 3e	492-1
256	69 2/10 x 3e	492-2
267	69 2/10 e x SLK	512-1
276	69 2/10 e x SLK	516-4
278	69 2/10 e x SLK	516-6
288	4n KS 1044 (32 1/18)	521-1
293	4n KS 1044 (32 1/18)	526-1
313	'50 2n (o.p.) from cross 60 x 169-1,2 (o.p.)	570-1
314	'50 2n (o.p.) from cross 60 x 169-1,2 (o.p.)	570-3
321	2n 82 x 166 950 B-opt '50-3 '52 GH	571-1
322	2n 82 x 166 950 B-opt '50-3 '52 GH	571-2
324	2n 82 x 166 950 B-opt '50-3 '52 GH	517-3
336	J x 4n C 28 (o.p.) GH	576-4
349	J x 4n	592-2
360	(J x 4n) F_1's K 4n	602-1
363	(J x 4n) F_1's K 4n	603-1
364	(J x 4n) F_1's K 4n	603-2
380	(J x 4n) x 4n F_1's	624-1
381	(J x 4n) x 4n F_1's	624-2
382	(J x 4n) x 4n F_1's	624-3
386	(J x 4n) x 4n F_1's	634-1
398	(J x 4n) x 4n F_1's	653-1
399	(J x 4n) x 4n F_1's	653-2
401	(J x 4n) x 4n F_1's	658-2
417	(J x 4n) x 4n op's '50	719-1
426	(J x 4n) x 4n Tift	751-1
427	(J x 4n) x 4n Tift	751-2
429	(J x 4n) x 4n Tift	751-5
433	(J x 4n) x 4n Tift	753-2
434	(J x 4n) x 4n Tift	760-1
436	(J x 4n) x 4n Tift	762-1
447	526 x 927 J (4n KS 1044)	796-2
458	526 x 4n 559	815-1
459	526 x 4n 559	815-2
474	911 x 4n 860	846-2
475	911 x 4n 860	846-3

Table 6. Dates of Heading of Sudangrass Rows and the Code Number to Represent each Date.

1953 Heading Date	Code Number
7/28	8
7/30	7
7/31	6
8/1	5
8/2	4
8/4	3
8/7	2
8/10	1

Leaf blight reactions were recorded 19 to 28 days after inoculation with ratings of 1 to 5, with 1 representing only traces of disease reaction and 5 representing the most severe reaction. Tables 3 and 4 show date of inoculation, days allowed for incubation period, and date disease reaction was recorded for each replication.

Lines as shown in Table 5 with leaf blight reading of 1 to 5 were planted in the 1953 sudangrass breeding nursery. Correlation coefficient was determined for reaction between greenhouse leaf blight and leaf blight under field conditions.

Methods Used in Determining the Potential Prussic Acid Content

The potential prussic acid content was determined in the manner developed by Hogg and Ahlgren (8). The method was modified to the use of paper standards as follows: 4 vigorous growing tillers 8 to 10 inches high were taken from the first four plants in each of 468 rows. The data from these samples indicated that 2 samples

from each row would be sufficient to give desired information. Two samples were taken from the remaining two hundred forty rows. When two of the suspended filter papers from the same row were identical in color, one was bleached in distilled water to compare with the liquid standards, the other one was labeled with a wax pencil and saved to be used as a paper standard. New paper standards were substituted frequently to avoid error caused by fading in color.

Note Taking Procedure

Detailed field notes were taken on the various rows of sudangrass for height, vigor, tillering, leafiness, date of heading, pigment color, and reaction to disease. Other characters such as; exceptionally coarse lines, extra good or poor seed yields, seed shattering, and lines maturing too late to produce good seed in Kansas were noted.

Helminthosporium leaf blight, Helminthosporium turcicum Pass. was the disease most common in the sudangrass breeding nursery. Bacterial stripe, Pseudomonas andropogonae Stapp. was identified in the nursery, but it was too limited to be considered a major disease except in a few lines.

The general level of disease occurrence was medium. Droughty climatic conditions presented an unfavorable environment for the spread of Helminthosporium leaf blight throughout most of the growing season. A few dried leaf blight lesions were noted on several rows August 10. Many fresh lesions were noted August 13. The first general wave of Helminthosporium leaf blight was noted

September 15 to 21.

The field notes were recorded in terms of numerals 1 to 5, with 1 representing the most desirable type of character and 5 the least desirable. In case of heading dates, the numeral 1 was used to designate the latest and 8 the earliest. This is shown in Table 6.

The height of the regrowth in the various rows of sudangrass was measured in inches, from the ground to the highest point on the plant. Three height readings were made in each row, the average of the three being taken to indicate the height of the regrowth of that particular row. Studies of the relationships between height of regrowth and other morphological characters were made by means of correlation coefficient.

Field notes on disease and mature plant characteristics were not taken until full maturity had been reached in order to allow each of these characteristics to reach full expression.

RESULTS

Major emphasis of this study was placed on 2 groups of material, which are: (1) 13 varieties of sudangrass in three replications and (2) 59 selected rows in the 1953 sudangrass breeding nursery. The data from varieties in the check blocks were analyzed by means of variance tables for percent dry matter contained in the fresh material, yields in pounds of dry matter on an oven dry basis, percent leaves in the dry matter, yields in pounds of leaves on a dry matter basis, and potential prussic acid content. Sixteen varieties in four replications were used for the

study of potential prussic acid.

Greenleaf and Wheeler were used for comparisons; because they were the only certified varieties of sudangrass in Kansas. Wheeler has been certified in Kansas for several years. Greenleaf was a new variety and was first certified for use in Kansas in 1953.

Characteristics of the 59 selected rows studied by variance tables were: number of leaves per stem, length of leaf, and width of leaf. Other characters studied were; prussic acid potential, height of regrowth, maturity dates, leaf blight and percent leaves in the dry matter of these rows. Relationships among the characters were studied by means of correlation coefficients.

The relationships between prussic acid potential in 51 clones of sudangrass in the greenhouse and the same clones after transplanting in the field, and Helminthosporium leaf blight reactions of 112 lines in the greenhouse and leaf blight reaction in the field were studied by means of correlation coefficients.

Pigment color of the various lines of sudangrass in the 1953 nursery was studied. A test of independence was made to determine if pigment color was associated with Helminthosporium leaf blight or prussic acid potential.

Percent Dry Matter

The variation in percent dry matter in the check block varieties are shown in Table 7. The percent dry matter for the first clipping had a range from (1949-D) 16.6 percent dry matter to (Wheeler) 27.7 percent dry matter. Wheeler was significantly

Table 7. Percent dry matter, 1953 sudangrass nursery (12 foot row sample, 13 varieties, 3 reps.).

Variety	Average percent First clipping D. M.	Average percent Second clipping D. M.	Percent D. M.
Wheeler	27.5	32.0	28.9
Piper	22.4	31.9	26.4
Nebr. 50722	17.4	27.7	25.7
K-2	22.2	28.5	24.2
S-1	20.3	24.0	23.3
337	18.6	26.1	22.9
1949-D	18.6	27.6	22.9
Greenleaf	18.5	25.1	22.6
K-3	19.9	24.7	22.5
Belts. Syn. IV	21.2	23.5	21.9
Tift	20.6	24.9	21.4
Nebr. 483172	18.8	25.7	20.9
Okla. 130	18.6	23.7	20.7

	L.S.D. 3.90-5% level 5.29-1% level		L.S.D. 3.55-5% level 4.81-1% level		L.S.D. 2.50-5% level 3.38-1% level	
Source	D/f	F	D/f	F	D/f	F
Variety	12	4.401**	12	5.50**	12	8.466**
Replication	2	1.981	2	.8157	2	.664
Error	24		24		24	
Total	38		38		38	

higher in percent dry matter than any other variety studied. Piper was second highest with 22.4 percent dry matter. Wheeler was the only variety studied that was significantly different from Greenleaf.

The percentage dry matter was higher in the second clipping than the first for all varieties studied. It ranged from a high of 32.0 percent (Wheeler) to a low of 23.5 percent (Beltsville Syn. IV). The percentage dry matter in Piper and Wheeler were significantly greater than Greenleaf. No other variety studied was significantly different from Greenleaf.

The percentage dry matter for the two clippings were determined for each variety studied. These averages ranged from a high of 28.9 percent (Wheeler) down to 20.7 percent (Okla. 130). Piper, Wheeler, and Nebr. 50722 were significantly greater in percent dry matter than Greenleaf. No other variety was significantly different from Greenleaf.

Yields in Pounds of Dry Matter

The average yields in pounds of dry matter for the first clipping ranged from a low of 1.97 pounds of dry matter for variety "337" to a high of 3.78 pounds of dry matter for Beltsville Syn. IV, as shown in Table 8. Beltsville Syn. IV was significantly higher than any other variety studied. Beltsville Syn. IV was followed by Okla. 130 with 2.91 pounds of dry matter. Greenleaf, Piper, and Wheeler exceeded Nebr. 50722, Nebr. 483172 and 337; were exceeded by Beltsville Syn. IV, however. Tift and Okla. 130 produced significantly more pounds of dry matter than K-2, S-1, 1949-D, Nebr. 483172, Nebr. 50722, and 337. Okla. 130 and K-3 were exceeded in pounds of dry matter produced by Beltsville Syn. IV. Okla. 130 was not statistically different from other varieties studied.

The average yields in pounds of dry matter in the second clipping ranged from a low of 0.57 pounds (Okla. 130) to a high of 1.51 pounds (Wheeler), as shown in Table 8. Greenleaf was significantly lower in pounds of dry matter in the second clipping than Wheeler, Nebr. 483172, Piper, and Nebr. 50722. Greenleaf was not statistically different from other varieties studied. Nebr. 483172 significantly exceeded Nebr. 50722, Beltsville Syn. IV, Tift, Greenleaf, Okla. 130, K-3, 1949-D, K-2, S-1, and 337.

Piper produced significantly more pounds of dry matter in this second cutting than Tift, Greenleaf, Okla. 130, K-2, S-1 and 337. Wheeler produced a greater number of pounds of dry matter in the second clipping than any other variety studied.

The total of the two yields gave an array from a low of 2.78 pounds of dry matter for variety "337" to 4.69 pounds of dry matter for Beltsville Syn. IV, as shown in Table 8. Greenleaf was significantly exceeded in pounds of dry matter only by Beltsville Syn. IV.

Table 8. Yield in pounds dry matter, sudangrass nursery check blocks (12 foot samples, 13 varieties, 3 reps).

Variety	1st. clip. D.M. lbs.	2nd clip. D.M. lbs.	Total yield D.M. lbs.
Beltsville Syn. IV	3.78	.91	4.69
Wheeler	2.73	1.51	4.30
Nebr. 483172	1.98	1.46	4.02
Piper	2.69	1.21	3.90
Tift	2.90	.87	3.77
Greenleaf	2.79	.81	3.60
K-3	2.49	1.09	3.58
Okla. 130	2.91	.57	3.48
1949-D	2.37	.93	3.30
K-2	2.44	.82	3.26
S-1	2.43	.75	3.18
Nebr. 50722	1.98	1.15	3.13
337	1.97	.81	2.78

	L.S.D. .528-5% level .716-1% level		L.S.D. .29-5% level .39-1% level		L.S.D. .89-5% level 1.20-1% level	
Source	D/f	F	D/f	F	D/f	F
Variety	12	6.406**	12	10.14**	12	3.097**
Replication	2	28.88**	2	10.18**	2	1.541
Error	24		24		24	
Total	38		38		38	

Greenleaf was not statistically different from the other varieties studied. Beltsville Syn. IV produced a larger total yield in pounds of dry matter than any other varieties except Wheeler, Nebr. 483172, and Piper. Wheeler and Nebr. 483172 exceeded Nebr. 50722 and 337 in total pounds of dry matter.

Percentage Leaves in the Dry Matter

The average percent leaves for the first clipping ranged from 44.44 percent for Wheeler to 70.75 percent for Greenleaf as shown in Table 9. Percentage leaves among the varieties studied in the first clipping were not significantly different.

An array of the percentage leaves in the second clipping ranged from Wheeler with 26.7 percent to Greenleaf with 65.1 percent. Greenleaf was significantly higher than K-3, S-1, Nebr. 50722, Piper, Nebr. 483172, and Wheeler.

Percentage leaves for the two clippings gave an array ranging from Wheeler with 37.7 percent leaves to Greenleaf with 68.1 percent leaves. The percent leaves for Greenleaf was significantly larger than in any other variety studied. Beltsville Syn. IV produced more leaves than Piper, Nebr. 483172, and Wheeler.

It was interesting to note that Greenleaf produced the highest percentage leaves in both the first and second clipping. Wheeler, Nebr. 483172, and Piper were lowest in percentage leaves for both clippings.

Table 9. Percentage leaves, sudangrass nursery 1953, 12 feet of row Check block (13 varieties, 3 replications).

Variety	Average percent leaves 1st clip.	Average percent leaves 2nd clip.	Percent leaves total D.M.
Greenleaf	70.75	65.1	68.1
Beltsville Syn. IV	53.53	57.7	60.3
K-3	63.19	48.7	58.9
1949-D	60.78	53.5	58.1
K-2	54.73	62.5	57.0
Tift	56.26	57.3	55.9
S-1	57.55	51.3	55.7
337	52.82	53.4	52.9
Nebr. 50722	55.10	45.5	51.2
Okla. 130	60.10	57.4	50.2
Piper	56.22	36.9	48.9
Nebr. 483172	47.75	30.7	41.8
Wheeler	44.44	26.7	37.7

			L.S.D. 13.17-5% level 17.85-1% level		L.S.D. 8.286-5% level 9.873-1% level	
Source	d/f	F	d/f	F	d/f	F
Variety	12	1.250	12	6.9**	12	8.403**
Replication	2	.899	2	11.99**	2	10.56**
Error	24		24		24	
Total	38		38		38	

Yields in Pounds of Leaves on A Dry Matter Basis

The yields in pounds of leaves on a dry matter basis are presented in Table 10. The average for each clipping and a total of the two yields are shown.

Beltsville Syn. IV produced 2.33 pounds of leaves in the first clipping. This was 0.4 pounds more than any other variety. The lowest number of pounds was 1.05 pounds in variety 337. The difference between the two varieties was 1.28 pounds. Greenleaf produced a significant higher number of pounds of leaves than Wheeler, 337, and Nebr. 50722.

The greatest yield of leaves in the second clipping was produced by Nebr. 50722 with 0.522 pounds. Okla. 130 produced 0.338 pounds of leaves. This was lower than any other variety. The variations in yield of leaves for the second clipping were not significant.

The greatest total number of pounds of leaves was 2.828 pounds produced by Beltsville Syn. IV. The lowest yield was 1.47 pounds produced by 337. The F values for total yield in pounds were not significant.

Potential Prussic Acid Content

Potential prussic acid content was determined for 16 varieties in replication numbers 1, 2, 3, and 4. Droughty conditions prevailed throughout the growing season and relatively high potential prussic acid as shown in Table 11 ranged from 566 ppm (Nebr. 483172) to 1939 ppm (Tift). Greenleaf, K-3, Tift, 372, Beltsville Syn. IV, S-1, K-2, Texas Sweet, 1949-D, Okla. 130, and Common were not significantly different from each other in potential prussic acid. They were significantly higher than Nebr. 483172, Nebr. 50722, and 337. Greenleaf was not significantly higher than certified Wheeler which has been safe for grazing purposes in Kansas.

The potential prussic acid content in Wheeler was not significantly higher than any other variety. Tift and Sweet 372 were significantly higher than Wheeler.

There was significant variation between replications. This may have been brought about by the variations in soil moisture

Table 10. Yield in leaves on dry matter basis, sudangrass nursery 1953. Check blocks (12 foot samples, 13 varieties, 3 replications).

Variety	Average 1st clipping yield lbs. D.M.	Average 2nd clipping yield lbs. D.M.	Total yield lbs. D.M.
Beltsville Syn. IV	2.33	0.498	2.828
Greenleaf	1.93	0.521	2.451
K-3	1.60	0.512	2.112
Tift	1.63	0.479	2.109
Okla. 130	1.71	0.338	2.048
Piper	1.50	0.442	1.942
1949-D	1.43	0.487	1.917
K-2	1.34	0.508	1.848
S-1	1.41	0.362	1.772
Nebr. 483172	1.25	0.431	1.681
Wheeler	1.21	0.415	1.625
Nebr. 50722	1.09	0.522	1.612
337	1.05	0.420	1.470

L.S.D. 0.62-5% level

Source	D/f	F	D/f	F	D/f	F
Variety	12	2.737*	12	1.111	12	2.1609
Replication	2	2.044	2	.606	2	2.176
Error	24		24		24	
Total	38		38		38	

conditions, which could not be seen under normal climatic conditions. The nursery sloped to the northwest, having better soil and more moisture in the northwest corner. Visible soil moisture differences could be seen in strips across the nursery with the advance of the growing season.

Table 11. Potential Prussic Acid in Parts per Million for 16 varieties, 4 check blocks. 1953 Sudangrass Nursery.

Variety	ppm
Tift	1939
372	1864
Beltsville Syn. IV	1667
S-1	1658
K-1	1651
Greenleaf	1649
K-2	1646
Texas Sweet	1591
1949-D	1585
Okla. 130	1449
Common	1392
Wheeler	1247
K-3	1222
337	728
Nebr. 50722	642
Nebr. 483172	566

Source of variation	D/f	F	LSD 594 ppm at 5% level
Variety	15	4.12**	794 ppm at 1% level
Rep	3	3.57*	
Error	45		
Total	63		

Average Number of Leaves, Length of Leaves, and Width of Leaves, from 59 Selected Nursery Rows

Considerable variation was found to exist in leaf characteristics. The variation in number of leaves per stem, length of the first leaf below the flag leaf, and the width of the first leaf below the flag leaf were highly significant. Variation between plants within rows was not significant.

Average Number of Leaves per Stem for 59 Selected Rows

The average number of leaves as shown in Table 12, ranged from (row 548) 3.6 to (row 161) 7.6 leaves per stem. Row number

161 (Sweet x Tift 246) had the largest number of leaves. Four Tift selections had the next largest in number of leaves.

KS 1044 selections ranged from 3.6 to 6.7 leaves per stem. Tift selections ranged from 4.1 to 7.3 leaves per stem. The various sources of material were distributed throughout the array. This indicates a greater variation between individual rows than between general sources of materials.

Row number 506 (Wisconsin observation from D. C. Smith 1952) was about midway between the extremes of the array with 5.7 leaves per stem. This was a significantly greater number of leaves than row number 11 (4.4), 50 (4.1), 66 (4.4), 67 (4.3), 140 (4.4), and 548 (3.6). Rows having a significantly greater number of leaves than 506 were: 84 (7.1), 87 (7.3), 121 (7.1), 161 (7.6), and 499 (7.1). Other rows were not significantly different from row number 506.

Table 12. Average number leaves per stem. (7 plants per row) 59 selected rows. Sudan nursery 1953.

1953 row no.	No. leaves per stem	1953 row no.	No. leaves per stem	1953 row no.	No. leaves per stem
161	7.6	470	6.1	20	5.4
87	7.3	104	6.0	59	5.4
84	7.1	257	6.0	64	5.4
121	7.1	359	6.0	349	5.4
499	7.1	452	6.0	472	5.4
187	6.9	75	5.9	386	5.3
234	6.7	143	5.9	482	5.3
441	6.7	488	5.9	168	5.1
501	6.7	8	5.7	352	5.1
488	6.6	40	5.7	460	5.1
132	6.5	374	5.7	528	5.1
201	6.4	506	5.7	347	5.0
439	6.3	524	5.7	357	5.0
218	6.1	493	5.6	384	5.0
457	6.1	2	5.4	545	5.0

Table 12. (concl.)

1953 row no.	:No. leaves :per stem	1953 row no.	:No. leaves :per stem	1953 row no.	:No. leaves :per stem
56	4.9	55	4.6	140	4.4
443	4.9	388	4.6	67	4.3
514	4.9	490	4.6	50	4.1
371	4.7	11	4.4	548	3.6
380	4.7	66	4.4		

L.S.D.
1.0 - 5% level
1.3 - 1% level

D/f	F
58	5.34**
6	1.54
348	
412	

Average Length of First Leaf Below the Flag Leaf for 50 Selected Rows

The average length of the first leaf below the flag leaf ranged from 11.6 inches to 24.26 inches as shown in Table 13. The F value for length of leaf between rows was highly significant. The difference between plants within the row was not significant.

Rows from the general sources of materials were distributed throughout the array. This indicates the variations were greater between individual rows than between general sources of material. When the two major sources of material were compared, it was found that KS 1044 selections ranged from 24.26 inches (row number 514) to 15.94 inches (row number 20). The Tift selections ranged from 13.28 inches (row number 121) to 21.8 inches (row number 59).

Row number 50 (Tift selection) had an average leaf length of 19 inches. This was approximately midway between the extremes of the array, making it a convenient point for comparison. It was significantly greater than row numbers 11 (15.9 inches), 20 (15.94

inches), 121 (13.38 inches), 143 (12.50 inches), 257 (14.71 inches), 349 (14.57 inches), 443 (15.62 inches), 444 (15.66 inches), 452 (13.16 inches), 572 (13.64 inches), 528 (15.69 inches), and 545 (11.60 inches). Rows with leaves significant longer than row number 50 were row numbers 187 (22.16 inches), 384 (23.14 inches), 457 (23.79 inches), 506 (23.44 inches), and 514 (24.26 inches). Other rows were not significantly different from row number 50.

Table 13. Average length of first leaf below the flag leaf (7 plants per row). 59 selected rows sudangrass nursery 1953.

1953 row no.	Average length of leaf	1953 row no.	Average length of leaf	1953 row no.	Average length of leaf
514	24.26	50	19.00	56	16.80
457	23.79	168	18.97	439	16.77
506	23.44	132	18.90	8	16.70
384	23.14	460	18.80	201	16.57
187	22.16	347	18.78	218	16.41
59	21.80	386	18.73	140	16.35
501	21.71	499	18.54	2	16.24
87	21.56	352	18.43	374	16.19
84	21.00	524	18.26	20	15.94
64	20.70	441	18.21	11	15.90
66	20.20	493	18.19	528	15.69
380	19.97	67	18.14	444	15.66
488	19.86	388	18.06	443	15.62
371	19.80	468	18.04	257	14.71
482	19.61	55	17.80	349	14.57
470	19.51	359	17.61	472	13.64
357	19.44	104	17.40	121	13.28
161	19.26	548	17.36	452	12.16
40	19.21	490	17.29	143	12.50
234	19.14	75	17.19	545	11.60

		D/f	F
L.S.D.	3.1 - 5% level	58	5.77**
	4.1 - 1% level	6	.92
		348	
		412	

Average Width of First Leaf Below the Flag Leaf of 60 Selected Nursery Rows

The differences in the width of leaf were highly significant, as indicated in Table 14. Variation between plants within the row was not significant.

Leaf width of row number 506 (Wisconsin observation) was 36.7 mm. This was significantly greater than row number 84 (Tift selection) with an average width of 31.7 mm. The leaf width of each row (506 and 84) was significantly greater than the leaf width of any KS 1044 selection. The leaf width of Tift selections ranged from 17.86 mm (row number 55) to 31.7 (row number 84). KS 1044 leaf widths ranged from 15.7 mm to 23.4 mm.

Row number 168 (Dwarf Waxy Kafir SA. 58714 x Sweet 161) compared favorably with row 84 with a leaf width of 31.4 mm.

Row number 488 (KS 1044 selection) had an average leaf width of 23.0 mm. This was about midway between the extremes of the array of leaf widths. This width was significantly greater than row numbers 2, 8, 55, 64, 66, 140, 143, 357, 371, 380, 386, 439, 443, 472, 480, 482, 490, 528, and 548. Row numbers with a leaf width significantly greater than row number 488 were row numbers 75, 84, 132, 161, 168, 388, 460, 501, and 506.

Relationships Between Number of Leaves per Stem, Length of First Leaf Below the Flag Leaf, Width of the First Leaf Below the Flag Leaf, Leaf Blight, and Percent Leaves in the Dry Matter, from 59 Selected Nursery Rows

Major emphasis in this portion of the study have been placed on relationships among the various leaf characters as shown by correlation coefficients in an effort to determine if morphological

Table 14. Average width of first leaf below flag leaf in millimeters. (7 plants per row). 60 selected rows. 1953.

1953 row no.	Av. width of leaf in mm.	1953 row no.	Av. width of leaf in mm.	1953 row no.	Av. width of leaf in mm.
506	36.7	499	23.3	357	19.3
84	31.7	488	23.0	371	19.3
168	31.4	104	22.9	386	19.3
388	28.0	493	22.9	66	19.1
132	27.9	50	22.4	482	19.0
460	27.3	359	22.4	64	18.9
501	27.1	121	21.9	472	18.9
75	26.9	187	21.9	8	18.7
161	26.6	20	21.7	59	18.7
441	26.0	470	21.6	140	18.7
257	25.0	40	21.5	2	18.1
201	24.9	11	21.4	143	18.1
87	24.1	56	20.8	444	18.0
457	24.0	352	20.4	528	17.9
468	24.0	384	20.1	55	17.8
234	23.9	347	19.9	439	17.6
524	23.7	349	19.6	218	17.1
452	23.6	374	19.6	548	17.0
67	23.4	380	19.4	490	15.7
514	23.4	443	19.4	545	15.0

L.S.D.	D/f	F
3.5 - 5% level	59	10.7**
4.6 - 1% level	6	.73
	354	
	419	

characters can be used in selecting better lines of sudangrass. The correlations coefficients for the relationships among these characteristics are shown in Table 15.

A highly significant, positive correlation coefficient of .6688 was found between the number of leaves per stem and the height of the regrowth. The association between number of leaves per stem and width of leaves was low as shown by a significant positive correlation .2918. The importance of the above associations is

not clear as neither the number of leaves per stem nor width of leaves was found to be significantly correlated with any other character.

A highly significant negative correlation -.6166 existed between the length of the leaf and potential prussic acid. This indicates that long leaves are often accompanied by a low prussic acid potential. A significant positive correlation coefficient .348 was found to exist between length of leaf and the height of the regrowth.

Significant positive correlations of .3346 were found to exist between leaf blight and percent leaves in the dry matter, and between leaf blight and date of maturity .4026. This is in agreement with previous reports (3, 10). A significant negative relationship -.3688 was found between leaf blight and height of the regrowth.

A significant negative correlation -.5405 was found between the percent leaves in the dry matter and the height of the regrowth. This could be expected as some of the rows were in the early head stage while others were in the late boot stage. This explanation is questionable, however, as the correlation coefficient between maturity dates and percent leaves in the dry matter was not significant.

No significant correlation was found between the prussic acid potential of 51 clones of sudangrass growing in the greenhouse and the prussic acid potential of the same clones after they were transplanted to the field, as shown in Table 16. This could be expected as environmental factors exert great influences on the

Table 15. Relationship between number of leaves per stem, length and width of first leaf below the flag leaf, and certain other characters in selected rows of sudangrass, expressed as correlation coefficients.

Relation of characters			D/f	Correlation coefficient
No. leaves per stem	x	Length of leaf	58	-.0786
" " " "	x	Width of leaf	58	.2918*
" " " "	x	Height of regrowth	58	.6688**
" " " "	x	Leaf blight 1953	58	.0196
" " " "	x	Percent leaves	58	-.1570
" " " "	x	Pot. Prussic Acid Content	58	-.063
Length of leaf	x	Width of leaf	58	.0378
" " "	x	Height of regrowth	58	.3484**
" " "	x	Leaf blight 1953	58	.1430
" " "	x	Percent leaves	58	.0787
" " "	x	Potential prussic acid content	58	-.6166**
Width of leaf	x	Height of regrowth	58	.1784
" " "	x	Leaf blight	58	.1222
" " "	x	Percent leaves	58	-.1145
" " "	x	Pot. prussic acid content	58	-.0016
Helminthosporium leaf blight	x	Percent leaves	58	.3346**
"	x	Pot. prussic acid content	58	-.2324
"	x	Height of regrowth	58	-.3688**
Percent leaves	x	Pot. prussic acid content	58	.0880
" "	x	Height of regrowth	58	-.5405**
Pot. prussic acid content	x	Height of regrowth	58	-.0649
Maturity	x	Length of leaf	37	-.0853
"	x	Width of leaf	37	-.1892
"	x	Pot. prussic acid content	37	-.0002
"	x	Percent leaves	37	-.2648
"	x	Leaf blight	37	.4026**
"	x	Number of leaves	37	.0000
"	x	Height of regrowth	37	-.1146

prussic acid potential.

A significant, but low, positive correlation coefficient .1941 was found between Helminthosporium leaf blight incidence of the 112 lines of sudangrass in field conditions and leaf blight

Table 16. Relationships between potential prussic acid content and Helminthosporium turcicum in the greenhouse, and under field conditions expressed as correlation coefficients.

Characters			d/f	Correlation Coefficient
Field leaf blight	x	greenhouse leaf blight	111	.1941*
Field pot. prussic acid content	x	greenhouse pot. prussic acid content	50	.109

produced by inoculating the same lines of sudangrass in the greenhouse, as shown in Table 16.

Association of Pigment Color with Leaf Blight and Potential Prussic Acid Content

The 1953 sudangrass nursery had 288 rows with tan pigments, and 294 rows with purple pigments. No previous effort had been made to select rows for this character. Therefore it is possible that some rows probably open-pollinated and were not entirely homozygous for this character.

The hypothesis was set up that helminthosporium leaf blight reaction was independent of pigment color. Classification of pigment color and leaf blight ratings are shown in Table 17. The chi-square (2.84 with 4 degrees of freedom) for a test of independence was insignificant. This indicates that the association between leaf blight susceptibility and pigment color are non significant in these lines.

Table 17. Chi-square independence test for pigment color and Helminthosporium leaf blight association.

Pigment color	Disease rating 1	2	3	4	5	Total
	Number of rows					
Tan	14	126	91	44	13	288
Purple	9	142	95	36	12	294
Total no. of rows	23	268	186	80	25	582

Chi-square 2.84 4 d/f

The hypothesis was set up that potential prussic acid content was independent of pigment color. Distribution for pigment color and potential prussic acid content in parts per million are shown in Table 18. The number of rows in each level of potential prussic acid content are about equal for each color of pigment. An independence test gave an insignificant chi-square (4.58 d/f = 2). The hypothesis that the prussic acid potential and pigment color are independent of each other is accepted with reluctance as the chi-square is only slightly below the 1 in 10 level. More study along this line might be in order.

Table 18. Chi-square independence test for pigment color and potential prussic acid content associations in parts per million.

Prussic acid content	Low 0-1000 ppm	Medium 1001-2000 ppm	High 2001 & over ppm	Total rows
Pigment color	number of rows			
Tan	63	153	73	289
Purple	50	180	62	292
Total rows	113	333	135	581

Chi-square 4.58 2 d/f

DISCUSSION

The extreme droughty conditions during the 1953 growing season were very influential in the yields in this study. The early maturing varieties and lines were well along in development before growth was retarded by insufficient moisture. The later maturing varieties and lines grew to maturity in more severely drought conditions. Frost and leaf discoloration made leaf blight reading unreliable for the varieties in the check blocks.

Highly significant variations were found to exist among the varieties studied, in four of the five characters studied. Varieties did not differ statistically in pounds of oven dry leaves produced. The difference in percent leaves in the dry matter was highly significant, however, This indicated that a large portion of the extra pounds of dry matter produced by some of the varieties was stems.

More emphasis was placed on this point when varieties were compared. Wheeler produced 1.62 pounds of leaves in 4.30 pounds of dry matter. Variety 337 produced 1.47 pounds of leaves in 2.78 pounds of dry matter. Beltsville Syn. IV produced 2.82 pounds of leaves in 4.69 pounds of dry matter. Greanleaf produced 2.45 pounds of leaves in 3.6 pounds of dry matter.

The variation among varieties in percent dry matter was significant. Two interesting observations were made from these data: (1) varieties that were low in dry matter content were generally late maturing varieties, (2) varieties with the lowest dry matter content generally produced the highest percent leaves in the dry matter.

These associations are difficult to explain as no significant correlation coefficient was found between maturity date and percent leaves for the selected nursery rows.

Greenleaf is a late maturing variety. It had the best combination of desirable characters of the 13 varieties studied except for Beltsville Syn. IV. It was relatively low in dry matter which indicates a high degree of succulence. Percent leaves in the dry matter exceeded all other varieties and was second to Beltsville Syn. IV in total pounds of leaves produced. Greenleaf was medium in total pounds of dry matter. It was not statistically different from Wheeler in potential prussic acid content. Readings for chinchbug injury for Greenleaf ranged from no injury to four.

Beltsville Syn. IV is medium in maturity. It was high on the list of desirable characteristics. It produced more pounds of dry matter, and leaves than any other variety studied. It was medium in percent leaves in the dry matter. The potential prussic acid content was not statistically different from Greenleaf or Wheeler. Reading for chinchbug injury for Beltsville Syn. IV ranged from no injury to four. It was very coarse. Future studies are needed with this type of variety as favorable moisture conditions may cause an undesirable leaf-stem ratio.

Wheeler was one of the top two in pounds of dry matter produced. Its lack of leafiness, extreme earliness, and moisture content places it lower on the list of desirable varieties. Although it was second high in total yield, it produced the lowest percentage leaves in the dry matter of any variety studied. Two varieties produced fewer pounds of leaves than Wheeler. It was

medium low in potential prussic acid. Although no disease readings were made on the varieties studied in the 1953 sudangrass nursery, past performances have proved Wheeler highly susceptible to Helminthosporium leaf blight.

The Nebraska varieties were medium in dry matter and percent leaves produced. They were low in pounds of leaves and in potential prussic acid content. Chinchbug injury was only slight for these varieties. They might be used in developing new lines of sudangrass with low potential prussic acid.

Oklahoma 130 had the highest moisture content of any of the other varieties. It was medium for other characteristics studied except maturity where it was the latest.

The poorest combination of characteristics was found in variety 337. It was medium in percent dry matter and percent leaves. It had the lowest total yield in pounds of dry matter and leaves of any other variety studied. It was favored, however, with a low potential prussic acid content. Other varieties studied were Piper, Tift, K-3, 1949-D, K-2, and K-1. They were found to be medium to low for all characters studied.

Highly significant variations were found in number of leaves per stem, width, and length of the first leaf below the flag leaf in the 59 selected nursery rows. Variations within the general sources of materials were greater than variations between general source of materials. This indicates that more emphasis should be placed on the individual plant or line than on general source of material when making selections for these characters. The question arises as to which of these characteristics are important for

use in breeding programs. Is there any association between these characteristics? How do they affect other desirable characteristics?

Correlation coefficient for percentage leaves in the dry matter and width of leaf -.114, length of leaf .157 and number of leaves per stem -.157 were very low. This indicates that the percent leaves in the dry matter was not significantly associated with either of these characteristics or the lack of one can be compensated for by an increase of the other.

A negative correlation coefficient (-.6166) for length of leaf and potential prussic acid content indicates that the long leaf is often accompanied by a lack of prussic acid.

Questions arising from this association are: (1) Is this a true linkage? (2) If it is, how many factors are involved? (3) Are these factors major or minor factors? Available information did not answer these questions.

Helminthosporium leaf blight reaction was associated with percentage leaves in the dry matter as shown by a significant positive correlation coefficient .343. A possible explanation of this association was given by Snyder (10). "The physical nature of the non-vigorous plants is such that water evaporates too quickly to permit inoculation by the pathogen."

Two possible explanations for the highly significant negative correlation coefficient -.540 between percent leaves and height of regrowth are suggested: (1) Tall stems have longer internodes, thus fewer leaves per inch of stem, (2) Stage of maturity, with the development of the peduncle, may have increased

the quantity of stems in the dry matter for some of the rows.

The low associations of pigment color with leaf blight resistance, and pigment color with potential prussic acid content have two possible explanations. First, pigment color was not associated with disease reactions nor potential prussic acid content for the lines studied. This would be in disagreement with previous reports (10). Second, a heterozygous condition for characters involved may have existed as no genetic study was made in the 1953 sudangrass breeding nursery.

SUMMARY

Variations in yields of dry matter, number of leaves per stem, length and width of first leaf below the flag leaf, and certain other characters of several varieties and experimental rows of sudangrass as well as relationships between these characters have been studied.

1. Significant variations were found to exist for several characters under observation during the 1953 growing season.

2. The thirteen varieties studied were significantly variable in moisture content, percent leaves in the dry matter, yields in pounds of dry matter and potential prussic acid content. They did not differ statistically in pounds of leaves produced.

3. Varieties with a low dry matter content were generally late maturing varieties and produced a high ratio of leaves to stems. The second cutting was higher in dry matter content than the first cutting for all varieties studied. No apparent association existed between the percent leaves in the dry matter for the

first and second cuttings.

4. Greenleaf had the best combination of characters of any variety studied. It was a late maturing variety, low in dry matter content, and was medium in pounds of dry matter produced. It had the highest percentage leaves in the dry matter of any variety studied. The prussic acid content was not statistically different from Wheeler. It was susceptible to chinchbugs, however.

5. Highly significant variations were found in number of leaves per stem, length and width of first leaf below the flag leaf in the 59 selected nursery rows. General sources of material were similar for these characteristics.

6. Number of leaves per stem was significantly and positively associated with width of the first leaf below the flag leaf and height of the regrowth. This character was not significantly associated with any other character studied.

7. A highly significant negative correlation coefficient was observed between length of leaf and potential prussic acid content. A significant positive correlation was observed between leaf length and height of the regrowth.

8. A significant positive correlation coefficient was observed between Helminthosporium leaf blight and percent leaves in the dry matter. A highly significant negative correlation coefficient was found for relationship of leaf blight and height of the regrowth.

9. A significant but low positive correlation coefficient was observed between leaf blight reaction of lines inoculated with the pathogen in the greenhouse and the same lines growing in the

breeding nursery.

10. No significant correlation coefficient was observed between potential prussic acid in clones of sudangrass growing in the greenhouse and in the same clones after they were transplanted to the breeding nursery.

ACKNOWLEDGMENT

The writer wishes to express his appreciation to Dr. R. C. Pickett, who supervised the experimental work and for counsel in tabulating the data; and to Dr. H. C. Fryer for counsel in tabulating the data.

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STUDIES OF YIELD, LEAFINESS, HCN, HELMINTHOSPORIUM LEAF BLIGHT, AND OTHER MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS IN CERTAIN SUDANGRASS VARIETIES AND LINES

by

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of Agriculture and Applied Science, 1950

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

The purpose of this experiment has been to study variations in yield, leaf characters, and prussic acid potential of several varieties and lines of sudangras, Sorghum sudanense (Piper) Stapf., and to determine if possible how these characters were related to each other and to certain other morphological and physiological characters. Highly significant variations were found for seven of eight characters studied.

Detailed field notes were taken on morphological characters and disease reactions. The prussic acid potential was determined by the tissue test method developed at the Wisconsin Agricultural Experiment Station by Hogg and Ahlgren.

Two cuttings were produced by the varieties studied in the 1953 sudangrass breeding nursery. The first cutting was harvested when the variety was in the early heading stage. The second cutting was permitted to grow until just before frost. Yield in pounds of dry matter, percent dry matter, yield in pounds of leaves, percent leaves in the dry matter, potential prussic acid were determined for each variety, and varietal differences were significant. Two interesting observations were made from these data: (1) Varieties that were low in dry matter content generally were late maturing varieties, (2) Varieties with the lowest dry matter content generally produced the highest percent leaves in the dry matter.

The varieties tested did not differ significantly in pounds of oven dry leaves produced. The difference in percent leaves in the dry matter was highly significant, however.

Fifty nine nursery rows representative of a wide range of

character types were selected. Samples of 800 to 1200 grams of green material were harvested for leaf studies from the regrowth. The first leaf below the flag leaf on each of seven stems was measured. These measurements consisted of width and length of leaf. The number of leaves on each stem was counted.

The variations in number of leaves per stem, length of the first leaf below the flag leaf, and the width of the first leaf below the flag leaf were highly significant. Variation between plants within rows was not significant.

Relationships among these characters and various other morphological and physiological characters were studied through the use of correlation coefficients. Number of leaves per stem was significantly and positively associated with width of leaf and height of regrowth. Length of leaf was significantly and negatively associated with prussic acid potential and positively with height of the regrowth. Helminthosporium leaf blight showed a significant, positive association with percent leaves, and a significant, negative correlation coefficient with height of regrowth. Percent leaves had a significant, negative correlation coefficient with height of regrowth.

No significant correlation coefficient was observed between prussic acid content in clones of sudangrass growing in the greenhouse and prussic acid content in the same clones after they were transplanted to the field.

A significant, but low, positive correlation coefficient was observed between Helminthosporium leaf blight reaction, produced by inoculating lines of sudangrass in the greenhouse, and Helmin-

thosporium leaf blight reaction of the same lines growing in the nursery.

Color of pigments was not found to be significantly associated with prussic acid potential or leaf blight reactions.